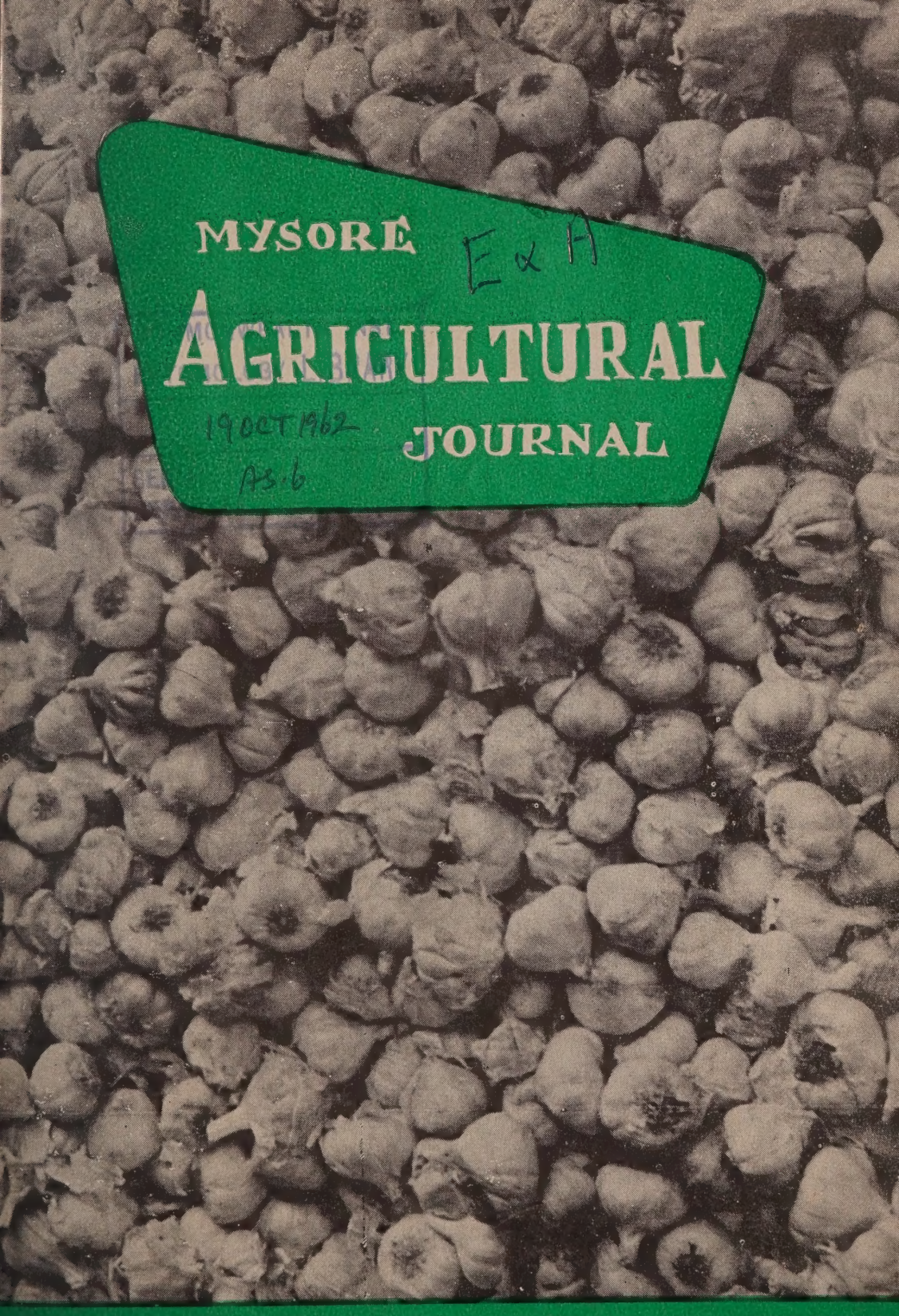

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Editorial

UNIVERSITY FOR AGRICULTURAL SCIENCES

NEWSPAPER reports reveal that it has been decided to establish a University for Agricultural Sciences for the Mysore State. It is understood that the expert team led by Dr. Ralph Cummings visited Bangalore recently and has been very much impressed with the facilities available for starting of the University. It is also understood that the State Government will shortly enact suitable legislation in this regard.

One such University has already been established at Rudrapur in Uttar Pradesh. The idea of such Universities in India has to a large extent been inspired by the successful working of Peoples' colleges in Scandinavian countries and the Land Grant Colleges in the U.S.A.

The present problem in the country is one of increasing agricultural production—the "replacing of agriculture based upon customs, habit and folkways with an agriculture based upon science". It also calls for an effective and much closer integration of Animal Husbandry, Agriculture and Horticultural Research, Education and Extension and the developing of a good programme of Agricultural Education in Secondary Schools to be closely linked with a Central Institution.

The chief objectives of such a University are to provide for maximum service to the rural parts through education (including adult educational objectives) in all aspects of rural life. The University aims to nurture a spirit of service, work and devotion of its staff and graduates to the development of rural Mysore State.

Being interested in an alround development of agriculture in Mysore State, we look forward with interest to the achievements of the above objectives through establishment of the University.

Research Articles

TRIALS WITH *PHOSTOXIN* FOR GRAIN FUMIGATION

By D. Seshagiri Rao[1] and M. Puttarudriah[2]

Introduction

Fumigation of food and seed grains has come into great prominence in recent years as a corollary to large-scale storage of grains by Central and State Governments for consumption and seed purposes. In spite of the application of scientific methods of storage, serious infestation and spoilage of some proportion of the stock, at some stage, is almost inevitable. Under such conditions fumigation is the only practical remedy if the affected stock is to be given a further lease of storage life.

Considerable work has been done in the last few decades on fumigation of grains, milled and processed products, plants and plant products, fabrics, etc. Several good fumigants have been evolved, many of which are in extensive use today. Hydrocyanic acid (HCN), Carbon disulphide (CS_2), Carbon tetrachloride (CCl_4), Ethylene dichloride (CH_2. Cl. CH_2Cl), Ethylene dibromide (CH_2 Br. CH_2 Br), Ethylene oxide [$(CH)_2$. O], Paradichlorobenze ($C_6H_4Cl_2$), and Chloropicrin (CCl_3 NO_2) are some of the fumigants in use today. Dosages, exposure periods, sorption factors, application techniques and hazards in handling, etc., have been thoroughly worked out in respect of various fumigants.

Common Fumigants and their Inherent Defects

Most of the common fumigants are volatile liquids with low boiling point and molecular weight, and insoluble in water. A few like paradichlorobenzene are solid. Other requisites in a good fumigant are that it should not leave excess toxic residues or cause injury, external or internal to the treated product, cause off-flavours or shorten storage life.

The main snag in fumigation is the hazard to human beings implied in the use of a highly volatile material, lethal to animal life. Fumigation techniques have however improved minimising the risk of bodily

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harm to the operators. Effective devices for detection of lethal concentrations of gas (such as halide detection lamp), construction of proper fumigation chambers or fumigatoria, use of gas-masks and other equipment by operators, and improved first-aid measures are some of the methods by which the inherent dangers of fumigation are being progressively reduced.

New Solid Fumigant

Samples of a new solid grain fumigant in tablet form, *Phostoxin*, manufactured by Degesch Deutsch Geseltshaft fur Schadlingsbekampfung, Germany, were received by us from M/s. Chika Private Limited, Bombay in 1957 through their local representatives for trials. It is stated to be pure Aluminium phosphide and Ammonium carbamate compressed to the consistency of marble. In the presence of moisture it is reported to decompose into Hydrogen phosphide (Phosphine gas), aluminium hydroxide, ammonia and carbon dioxide, such decomposition, starting one hour after exposure and ending 3 to 5 days afterwards. The carbon dioxide evolved affords protection against any fire hazard and thus the fumigant is reported to carry its own fire-extinguisher.

Experimental Details

Phostoxin is reported to be in use as a grain fumigant in Germany for a number of years. It has been used successfully for disinfesting bulk grain in Turkey. It has also been tested in U.K. and U.S.A. The samples received by us were critically tested thrice against a heavy infestation of (1) *Sitophilus oryzæ*, L. and (2) *Sitotroga cerealella*, Oliv on bulk stocks of maize cobs stored in a private godown, as follows:

Trial No. 1 .. In room with tiled roof—Vol. 2,688 c. ft., 30 tablets.

Trial No. 2 .. In two interconnected rooms, with tiled roof, plastered underneath—4,400 c.ft., 90 tablets.

Trial No. 3 .. In two interconnected rooms, with tiled roof, plastered underneath—4,400 c.ft., 60 tablets.

In these rooms infested maize cobs were piled loosely on the floor and on wooden racks. There were no easy means of estimating the weight of the material or the space occupied by it.

The dosages of *phostoxin* required, mentioned in literature, are invariably with reference to the weight of grain to be fumigated, not of the space occupied by it or the capacity of the chamber. Lindgren *et al.* have however worked out the dosages required, in terms of mgm./l. for complete mortality of different pests in laboratory trials. The average dosage in these 36 trials was 6 mgm./l., corresponding to 0·36 lb.

or 60 tablets per 1,000 c.ft (1 tablet = 3 gm.). Other workers have only indicated the number of tablets for a given weight of grain, such as 240 tablets per 1,000 bushels, 6 to 15 or 20 tablets per ton and so on.

Since there was considerable variation in the dosages needed, obviously depending on the storage method and other factors, we had to proceed on an empirical basis. In the packing received by us there were 3 tubes of 30 tablets each. Since it was not advisable to use only a part of the contents of a tube and keep back the remaining tablets, we had to use 30 tablets or multiples thereof, in these fumigations. The dosages employed were 11, 20 and 13·6 tablets per 1,000 c.ft respectively in these trials. They are much lower than the figures arrived at from the data of Lindgren *et al.* (*Loc. cit.*)

The windows were first closed and made airtight with mud plastering and similarly the outer doors after fumigation. Five days were allowed for fumigation.

In the first fumigation 30 tablets were thrown in quickly all over the room and the door was then closed and plastered over. In the other two cases the tablets were exposed on small slips of paper placed on the heaps and on the floor. Tablets were distributed on these pieces of paper carefully, time taken being about 10–15 minutes.

When the rooms were opened 5 days later, there was a faint smell in the room which disappeared in about an hour with the doors and windows kept open. The tablets had mostly all crumbled into ashy powder. The paper bits were collected carefully with the powder and buried in a hole in the ground.

Results and Conclusions

There was a complete kill of adult insects in the fumigated rooms. It was not easy to determine the ovicidal or larvicidal effect of the fumigation. (Some cobs taken out of the fumigation chamber and confined in jars in the laboratory showed no signs of infestations.) The interval between two consecutive fumigations was a little more than 3 months, probably showing that there could not have been complete mortality of immature stages, particularly eggs. Unless laboratory trials are taken up to settle this point, it is not possible to say whether *phostoxin* has ovicidal property or not. It is possible that it is lethal to insect eggs but the dosage employed in these trials may not have been sufficient.

In conclusion, *phostoxin* is easy to handle being in tablet form. Since decomposition starts one hour after exposure, there will be enough time for proper distribution of the tablets in the store. But the thin metal tubes in which they are packed are likely to get slightly jammed or dented with the result that the tablets do not easily roll out, or are

broken and reduced to powder inside the tubes. It is a great advantage that *phostoxin* does not require complete airtight conditions. The dosages have not been prescribed in the available literature with reference to the cubical capacity of the fumigation chamber. This information is necessary to deal with rooms which are only partially filled with infested material. This material is not easily available at present, nor is its cost known so that is not possible to speak about its economics with reference to other fumigants.

ACKNOWLEDGEMENTS

In conclusion we wish to record our thanks to M/s. Rangaswami and Company, Sri Narasimharaja Road, Bangalore, for having kindly supplied the sample material and to Mr. G. M. Jacoby, Golden Corn Company, Bangalore, for placing his stores at our disposal.

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BEHAVIOUR OF JAYADHAR COTTON WHEN GROWN AS AN INTERCROP WITH GROUNDNUT

By C. B. Divekar*

Introduction

With the successful introduction of groundnut in the transitional tract of Dharwar area, where the rainfall is assured, the farmers have realised the importance of growing this legume crop. The growing of groundnut and cotton crops together is not uncommon, on account of the differential growth periods, feeding zones and climatic requirements of these crops. As such growing groundnut and cotton crops together form an ideal mixture.

The author has noted (data published elsewhere) that the yield of cotton when grown as an intercrop decreases as compared to its yield when grown alone. Ducker and Hoyle (1948) have reported the reduction in the yield of cotton when grown as a mixture. Roberts (1946) has reported that long days and low temperatures favour the occurrence of excretion of nitrogen from the legumes which would benefit the growth of non-legumes grown in association. These environmental conditions, namely, the long days and low temperatures do prevail during the growing period of groundnut crop in this region. But even then it is observed that there is considerable reduction in the yield of cotton crop when grown as an intercrop with groundnut, as compared to when grown alone. It was thus considered to go into the details of the causes of reduction in the yield of cotton when grown as an intercrop with groundnut. The present paper is an attempt to answer a few points in this direction.

Materials and Methods

Pure seed of groundnut variety *Spanish-Improved*, with erect growing habit, and Cotton variety *Jayadhar* (*Gossypium herbaceum*) having 90 to 95% germinating capacity were utilised throughout the experiment. The experiment was carried out at the Agricultural Research Station, Dharwar (Mysore State), with the following three treatments:

(A) Entire cotton.

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(B) Groundnut intercropped in cotton.

(C) Groundnut receiving P_2O_5 at the rate of 50 lb. per acre intercropped in cotton.

The experiment with the above three treatments was laid out in the randomised block design with 6 replications, and was conducted from 1949–50 to 1957–58. From 1958–59 season the experiment was modified and treatments with nitrogenous manures given to the entire cotton and also to the intercropped cotton were incorporated. However, the two treatments, namely, the entire cotton and the cotton with groundnut intercropped in it, were retained to serve as the controls and the observations were recorded in these two treatments. The modified experiment was laid out in the randomised block design with 4 replications. The main object of this paper is to give the comparative performance of the cotton crop when grown as an entire crop and also when grown as an intercrop and as such only these two treatments have been referred to in the text.

The preparatory tillage and other operations were carried out as per normal practice. The farm-yard manure was applied at the rate of 5 cartloads per acre to the jowar crop which was grown as a rotational crop. Groundnut kernels were dibbled spaced 2 feet apart to facilitate intercropping of cotton crop with normal 2 feet spacing. Both the crops were grown under rainfed conditions.

The measurements for height of the crop has shown that the cotton plants in the entire cropping grow taller than when they are grown as an intercrop with groundnut. The differences in heights occur at a very early stage of the crop growth and continue to remain till the harvest of the cotton crop. With the result the plants in the entire cotton grow in height, almost about twice as much as the ones in the intercropped conditions. The height measurements for 1954–55 season have been presented.

The factors of harvest have been studied on 10 plants selected at random in each replication in 1956–57 season. In the year 1957–58, observation on the number of cumulative flowers and cumulative bolls per plant was studied on 10 random plants in each replication. This was recorded on alternative days commencing from 15th January 1958 to 23rd April 1958. In the subsequent year (1958–59) the observations on the number of bolls harvested and the weight of kapas obtained therefrom was recorded in the enitre net plot of $32' \times 20'$ dimension in each replication. The kapas was picked at a fixed interval of 10 days in this season.

Experimental Results and Discussion

The yield of kapas per acre when cotton is grown as an entire crop (A) and when grown as an intercrop with groundnut (B) is given in Table I from 1949–50 to 1958–59. The yield of kapas in the third treatment, namely, when groundnut grown as an intercrop receiving P_2O_5 at the rate of 50 lb. per acre (C) is also given since it formed one of the treatments in the experiments from 1949–50 to 1957–58 season.

It can be seen from Table I that the kapas yield is more in almost all years when cotton is grown as an entire crop. Further it is generally noted that the kapas yield in the treatment with entire cotton is significantly more in its first picking as compared to the yield obtained when grown as an intercrop with groundnut; and also that the yield of kapas in the intercropped cotton is generally significantly more in its second picking as compared to the one obtained in the entire cotton crop.

In Table II are given height measurements of cotton crop when grown as an entire crop and also when grown as an intercrop with groundnut in 1954–55 season. Figures given in Table II are the average height measurements recorded on 30 random plants in 6 replications at various periods of growth.

It could be seen from Table II that the height of cotton plants is more in the entire cotton crop (A) as compared to the one when cotton is grown as an intercrop with groundnut (B and C). The reason is obvious. The cotton-seeds were dibbled in all the three treatments on 5th August 1954. By this time the groundnut crop in the treatments B and C had attained 44 days growth and had practically finished the vegetative growth phase. Further, groundnut was grown with rows spaced 2 feet apart to accommodate intercropping of cotton. The spacing is twice the normal spacing of groundnut, which facilitated the plants to grow better. Thus the cotton-seedling in its very early stage could not get sufficient light and seration and was made to grow in somewhat nutrient-depleted soil portion as compared to the entire cotton crop.

On account of the initial advantages, the plants in the entire cotton plots could grow taller and continued to produce more vegetative growth. With the harvest of the intercropped groundnut in October, by uprooting the groundnut plants, the soil between the two rows of cotton was exposed in these treatments (B and C). This reduced the moisture content in the soil which was already becoming the limiting factor. Further, on account of the initiation of the flowering buds in the cotton plants in October, the water requirements of the plants increased. As such the intercropped cotton plants had to face a double disadvantage. This is, hence, the cause of the delay observed in the initiation of

TABLE I

Yield of kapas per acre in different pickings in the three treatments from 1949–50 to 1957–58

	Treatment	1949–50	1950–51	1951–52	1952–53	1953–54	1954–55	1955–56	1956–57	1957–58	1958–59
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	HARVEST										
A.	1st ..	467·0	124·7	404·6	355·4	338·0	845·7	310·0	329·7	275·2	137·0
	2nd ..	117·1	305·8	12·4	214·7	128·5	17·4	133·0	144·8	132·0	187·0
	3rd ..	..	161·0	..	78·6	5·6	9·7	24·9	67·6	57·0	119·0
	4th ..	..	..	..	3·7	..	..	..	..	36·7	23·2
	TOTAL ..	584	591	417	652	472	872	467	542	500	466
B.	1st ..	157·3	136·1	406·0	227·6	172·4	377·5	203·9	68·3	90·0	204·0
	2nd ..	95·6	344·8	27·2	316·1	187·5	50·8	224·0	158·8	132·6	178·0
	3rd ..	..	140·6	..	48·4	39·6	15·1	13·6	113·6	78·0	85·0
	4th ..	..	..	..	6·0	..	..	..	..	111·3	25·5
	TOTAL ..	252	621	433	598	399	443	441	340	411	492
C.	1st ..	162·6	149·8	434·8	271·5	154·2	508·2	226·2	61·5	127·8	..
	2nd ..	86·5	297·1	30·3	272·2	167·8	45·3	196·9	175·4	169·8	..
	3rd ..	..	99·8	..	31·7	43·8	18·1	17·7	176·9	88·5	..
	4th ..	..	..	..	39·6	..	..	..	..	102·7	..
	TOTAL ..	249	546	465	615	365	571	440	413	488	..

TABLE II

Height measurements of cotton plants in the three treatments after various periods of crop growth in 1954–55 season

Treatment	Number of days after sowing			
	75	105	125	180
Entire cotton (A) ..	19·1″	23·9″	25·0″	37·2″
Intercropped cotton with groundnut (B)	11·7″	13·0″	14·4″	25·0″
Intercropped cotton with groundnut wherein groundnut receives P_2O_5 at 50 lb. per acre (C)	13·0″	14·8″	15·3″	24·8″

flowering buds in the intercropped cotton. The delay in the commencement of flowering in the intercropped cotton plants was to the extent of 15 days as compared to the entire cotton plants.

To find out the exact cause of the reduction in the yield of kapas when cotton is grown as in intercrop with groundnut, 10 plants at random per replication were selected in all the six replications and the number of bolls harvested and the weight of kapas obtained from these bolls, in every picking, was studied in 1956–57 season and is given in Table III.

It could be seen from Table III that there is not much difference in the average weight of kapas per boll between the treatment with entire cotton (A) and the treatment with cotton grown as an intercrop (B). Hence the differences observed in yields per acre in Table I in these two treatments must be due to the number of bolls harvested per plant. It is observed that the cotton plant when grown as an entire crop produces 30·35% more number of bolls per plant in the first picking as compared to the number of bolls in plants when raised as an intercrop. But subsequently in the second and the third pickings respectively, the number of bolls harvested per plant were actually less in the treatment entire cotton by 10·4% and 172·0% as compared to the one with intercropped cotton. This is probably the cause of the significantly more kapas yield, in the second and third pickings in the treatments with intercropped cotton (B and C) than the treatment with the cotton grown as an entire crop (A).

TABLE III

The number of bolls harvested per plant and the weight of kapas obtained therefrom in different pickings in the three treatments in 1956–57 season*

Treatment	Observations	Pickings			Total
		1st	2nd	3rd	
A. Entire cotton ..	No. of bolls/plant	3·78	3·92	0·61	8·31
	Total weight of kapas gm.	4·90	4·33	0·77	10·00
	Weight of kapas/boll gm.	1·29	1·10	1·26	Average 1·29
B. Cotton intercropped with groundnut	No. of bolls/plant	2·90	4·00	1·66	8·56
	Total weight of kapas gm.	3·63	4·87	1·88	10·38
	Weight of kapas/boll gm.	1·25	1·21	1·13	Average 1·21
C. Cotton intercropping with groundnut receiving 50 lb. P_2O_5	No. of bolls/plant	1·55	5·23	3·01	9·79
	Total weight of kapas gm.	2·25	6·97	3·71	12·93
	Weight of kapas/boll gm.	1·45	1·33	1·23	..

* Average of 60 plants.

The total harvest position gives an interesting picture. The kapas yield per boll in the entire cotton crop and in the intercropped cotton remains more or less the same. The number of bolls harvested per plant is found to be more in the treatment with intercropped cotton as compared to the one when cotton is grown alone. The increase is found to be 0·25 boll per plant. No matter how small this increase is there is absolutely no reason for the entire cotton crop to give more kapas yield than when cotton is grown as an intercrop. However, the yield data, as recorded in Table I indicate that the entire cotton crop yields 201 lb. more kapas per acre in this season than the one with groundnut intercropped in it.

In order to confirm the observations on 10 plants recorded in the year 1956–57, detailed observations on the cumulative number of flowers and bolls per plants were recorded in the year 1957–58. The data have been presented in Table IV after deducing the same to per-plant basis.

TABLE IV

Cumulative number of flowers and bolls per plant in the entire and in the intercropped cotton

Date	Cumulative number* of flowers per plant		Cumulative number* of bolls per plant	
	Entire cotton	Inter-cropped cotton	Entire cotton	Inter-cropped cotton
January 1958:				
15th	1·20	0·60	4·0	1·5
17th	0·70	0·50	5·0	1·9
19th	0·50	0·45	5·8	2·3
21st	0·70	0·40	6·3	2·8
23rd	0·50	0·50	6·7	2·8
25th	0·50	0·50	7·1	3·2
27th	0·60	0·70	7·5	3·6
29th	0·70	0·80	7·8	4·2
31st	0·50	0·80	8·4	5·0

* Average of 60 plants.

TABLE IV (*Contd.*)

Date	Cumulative number* of flowers per plant		Cumulative number* of bolls per plant	
	Entire cotton	Inter-cropped cotton	Entire cotton	Inter-cropped cotton
February 1958:				
2nd	0·60	0·80	8·4	5·6
4th	0·50	0·80	8·6	5·8
6th	0·40	0·90	8·9	6·4
8th	0·40	0·90	8·9	7·3
10th	0·20	0·70	9·1	7·8
12th	0·20	0·90	8·6	8·2
14th	0·20	0·90	8·2	7·1
16th	0·10	0·60	7·7	9·5
18th	0·1	0·80	8·3	9·4
20th	0·10	0·70	6·6	12·5
22nd	0·00	0·80	8·0	10·2
25th	0·00	0·70	6·3	13·4
27th	0·10	0·50	7·8	10·4
March 1958:				
1st	0·00	0·40	7·7	10·6
4th	0·00	0·50	7·7	10·7
7th	0·00	0·20	4·2	10·2
10th	0·00	0·20	3·9	9·7
12th	0·00	0·20	2·2	8·3
14th	0·10	0·10	2·1	8·3
17th	0·00	0·20	2·2	8·0
19th	0·00	0·00	1·0	5·6
21st	0·10	0·00	1·0	5·6
24th	0·00	0·00	1·1	5·4
26th	0·00	0·00	0·5	3·8
28th	0·00	0·00	0·5	3·4
31st	0·00	0·00	0·6	3·4
April 1958:				
2nd	0·00	0·00	0·4	1·8
4th	0·10	0·00	0·4	1·8
7th	0·20	0·00	0·5	1·7
9th	0·10	0·00	0·6	0·5
11th	0·10	0·00	0·7	0·5
14th	0·10	0·00	0·6	0·3
16th	0·10	0·00	0·6	0·3
18th	0·10	0·00	0·7	0·3
21st	0·00	0·00	0·7	0·3
23rd	0·20	0·00	..	..

* Average of 60 plants.

It can be seen from Table IV that the flowering in the treatment with entire cotton declines from 23rd January practically throughout the season as compared to the one in the treatment with intercropped cotton (B). The flowering is at its peak in the intercropped cotton plants on 13th February and at this time the plants in the entire cotton treatment were bearing approximately the minimum number of flowers.

The cumulative number of bolls per plant was observed to be maximum on February 10th in the treatment with entire cotton. The boll number steadily rose from 4 bolls per plant in January to 8·4 bolls per plant by the end of January 1958. During the month of February the boll number increased to a little extent and remained more or less constant. The decline commenced in the month of March and from 19th March there remained practically one boll per plant.

In the treatment with intercropped cotton the number of bolls per plant steadily increased from January and they were at their peak on 23rd February. They remained at a fairly high level from 18th February to 13th March after which a decline commenced.

Thus it can be seen that the bolling curve in the entire cotton crop with its peak on 10th February is shifted ahead when the crop is grown as an intercrop with its peak on 22nd February. The sharp decline in the bolling curve is due to the different pickings.

The number of bolls harvested at the interval of seven days and the weight of kapas obtained from these bolls in the entire cotton and the intercropped cotton is given in Table IV.

It could be seen from Table IV that the boll weight remains more or less constant both in the entire cotton and the intercropped cotton. It is further observed that in the case of entire cotton crop 47·7% of the total harvest is obtained in the 1st picking and 25·4% in the 2nd picking, 16·4% in the 3rd picking and 6·4% in the 4th picking. Whereas in the case of intercropped cotton the position is little different. In the 1st picking 8·3% of the total harvest is obtained and in the subsequent pickings the kapas obtained is 15·5%, 22·1%, 19·9% and 18·5%. This explains the cause of significantly higher kapas yields obtained in the entire cotton in its 1st picking and also significantly lower yields in the 2nd and 3rd pickings, as compared to its produce in the intercropped conditions.

The total performance, in respect of harvest of selected plants during this year also, indicates that there is no reduction in the number of bolls per plant in the intercropped cotton as compared to the entire cotton. Similar is the position about the total amount of kapas harvested per plant,

TABLE V

The number of bolls harvested per plant weight of kapas obtained per plant and their percentages to the total harvest in the three treatments*

Date of harvest	Entire cotton A		Cotton intercropped with groundnut B		C	
	Number of bolls	Weight of kapas gm.	Number of bolls	Weight of kapas gm.	Number of bolls	Weight of kapas gm.
4–3–1958	3·49 (48·9%)	3·94 (47·7%)	0·69 (8·3%)	0·75 (7·2%)	1·02 (10·5%)	1·09 (10·4%)
11–3–1958	1·84 (25·7%)	2·10 (25·4%)	1·29 (15·5%)	1·58 (15·3%)	2·89 (30·0%)	2·49 (23·8%)
18–3–1958	1·09 (15·2%)	1·36 (16·4%)	1·84 (22·1%)	3·02 (29·3%)	2·49 (25·8%)	3·23 (30·9%)
25–3–1958	0·49 (6·8%)	0·54 (6·5%)	1·59 (19·0%)	1·72 (16·6%)	1·64 (17·0%)	1·82 (17·4%)
1–4–1958	0·15 (2·0%)	0·19 (2·3%)	1·54 (18·5%)	1·85 (17·9%)	1·14 (11·8%)	1·38 (13·2%)
8–4–1958	0·02 (0·2%)	0·02 (0·2%)	1·16 (13·9%)	1·18 (11·4%)	0·46 (4·7%)	0·44 (4·2%)
15–4–1958	.. ..	..	..	..	..	..
21–4–1958	0·07 (0·9%)	0·10 (1·2%)	0·20 (2·4%)	0·20 (1·9%)	..	..
TOTAL ..	7·15	8·25	8·31	10·30	9·64	10·45

Figures in the parenthesis are the percentages to the total. * Average of 60 plants.

Consistently similar observations for two years showed that the number of bolls per plant, weight of kapas harvested per boll and the total weight of kapas obtained per plant is not less in the intercropped cotton as compared to the entire cotton. Thus, the question remains as to why the total yield of the entire experiment should show reduction in the yield of kapas when the cotton is grown as an intercrop as compared to when grown as an entire crop.

Hence in order to further confirm the indications obtained in the years 1956–57 and 1957–58 with regards to the number of bolls harvested per plant and the weight of kapas obtained from these bolls, it was thought worthwhile to study these aspects of the harvest in the entire net plot in the year 1958–59. The observations recorded in Table V are the average performance per plant in the entire cotton and in the intercropped cotton treatments.

It could be seen from Table VI that the average weight of kapas obtained per boll is 1·66 gm. in the entire cotton and 1·83 gm. in the intercropped cotton. The yield of kapas is observed to be more in the intercropped cotton by 1·57 gm. per plant as compared to the entire cotton treatment.

Hence, in all the three years under study it is observed that the number of bolls per plant and weight of kapas per plant is more in the intercropped cotton as compared to the entire cotton crop. There are, however, no outstanding changes in the boll weight on account of growing cotton as an intercrop with groundnut. Similar increase in the boll number per plant has been reported by Dastur (1959) when nitrogen was applied to cotton.

Reynolds *et al.* (1935) found a high number of fruiting branches with the addition of nitrogen. In the case of boll, increase in number was noticed only in late pickings; in the early ones, there was actually reduction in the number of bolls with increasing nitrogen supply, obviously due to its delaying effects. These observations are similar to the one obtained in the intercropped cotton plants in the present study. This indicates that the intercropped cotton plants behaved as if they were supplied nitrogenous manures. This is possible on account of the nitrogen made available from the legumes.

It is seen from the yield data of the kapas given in Table I that the entire cotton crop produces more kapas as compared to the cotton crop when grown as an intercrop with groundnut. This is however contrary to the observations recorded in 1956–57 and 1957–58 seasons on the selected plants and the observations in the net plot in the year 1958–59. This indicated that there should be some defect in the final population of the cotton plants in the two treatments. This is likely on account

TABLE VI

The number of bolls harvested and the weight of kapas obtained per plant in the treatment entire cotton (A) and the intercropped cotton (B) in 1958–59 season

Date of harvest	Entire cotton (A)		Cotton intercropped with groundnut (B)	
	Number of bolls per plant	Weight of kapas per plant gm.	Number of bolls per plant	Weight of kapas per plant gm.
7–2–1959	2·16 (29·5%)	3·78 (30·9%)	..	..
17–2–1959	2·69 (36·7%)	4·91 (40·1%)	..	..
27–2–1959	2·03 (27·7%)	2·96 (24·2%)	3·09 (41·0%)	5·72 (41·4%)
9–3–1959	0·44 (6·0%)	0·57 (4·66%)	2·63 (34·9%)	5·00 (36·2%)
19–3–1959	..	..	1·27 (16·8%)	2·36 (17·1%)
2–4–1959	..	..	0·53 (7·0%)	0·71 (5·14%)
TOTAL ..	7·32	12·22	7·52	13·79

of the unfavourable conditions to the cotton seedlings during the initial growth of the plants, in the treatment where groundnut was grown as an intercrop. This presumption is substantiated from the observations recorded in the year 1958–59. In this year utmost care was taken to maintain equal population in the intercropped cotton and the entire cotton treatment. Even then the number of plants considerably reduced on account of death of the seedlings in the intercropped cotton. The final plant count in all the four replications is given below in the two treatments.

The number of plants in the treatment with entire cotton (A) and the intercropped cotton (B) in the net area

Treatment	R_1	R_2	R_3	R_4	Total
1. Entire cotton (A) ..	272	306	265	229	1072
2. Cotton intercropped with groundnut (B)	235	242	253	222	952

It is thus seen that there is reduction in the stand of the crop on account of growing cotton plants as an intercrop with groundnut. During this year the reduction in the stand of the crop being of a small magnitude did not adversly affect the yield.

Hence it could be stated that during the previous years the real cause of reduction in the yield of kapas when cotton was grown as an intercrop with groundnut is due to the low stand of crop and not due to low bearing capacity of the plants.

Further studies on factors affecting the stand such as the germination of the seed, moisture content of the soil, etc., could elucidate the cause of low stand in the intercropped cotton as compared to the cotton when grown as an entire crop.

Summary

(1) Behaviour of cotton plants when grown as an entire crop and as an intercrop with groundnut was studied from 1948–49 to 1958–59.

(2) The kapas yield when cotton was grown as an entire crop was observed to be more than when it was grown as an intercrop with groundnut. The reduction in the kapas yield on account of intercropping cotton was consistent.

(3) The observations recorded on 10 plants showed consistently for two years in 1956–57 and 1957–58 seasons, that the boll weight remained more or less the same in both the entire cotton and intercropped cotton.

However, the number of the bolls produced per plant and the weight of kapas obtained per plant was more in the intercropped cotton as compared to the entire cotton. This behaviour was further confirmed in the 1958–59 season when the entire net plot was observed for the boll number and weight of kapas per plant.

(4) The real cause of reduction in the yield of kapas when cotton was grown as an intercrop with groundnut appeared to be due to the low stand of the crop in this treatment as compared to the stand in the

entire cotton plot. This is possible on account of unfavourable conditions to which the cotton seedlings are subjected to during the first 70 days of their growth till the harvest of the intercropped groundnut.

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EFFECT OF PERIODICAL TOPPING OF WESTERNS-1 (*G. HERBACUM* L. RACE *ACEREFOLIUM*) COTTON

By K. Krishna Murthy*

Introduction

An experiment was laid out to study the effect of periodical topping on Westerns-1 cotton during 1958–59 and 1960 *rabi* season at the Agricultural Research Station, Hagari. The results of these trials are reported here.

Material and Methods

The experiment was laid out on medium black cotton soil in a randomised replicated design. There were four replications and six treatments.

Treatments	Topping days from sowing	
	1958–59	1959–60
A	53	62
B	71	69
C	81	77
D	90	85
E	100	93
F	Control	

The sowings were done on 22nd and 23rd September 1958 and 1959 respectively. The sowings were delayed by three weeks in both the years for want of rains. The total rainfall during these years was 14·3″ and 18·2″, while rainfall during crop period was 4·0″ and 5·3″ respectively. Topping was done by nipping of the top 2–3 nodes on the main axis during the scheduled dates.

Results

The experimental findings based on the economic characters of the crop are summarised below:—

(1) *Effect of topping on yield and earliness.*—Yield factor is the major test of superiority of the treatments under trial. Table I gives

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TABLE I

Effect of topping on yield and earliness of Westerns–1 cotton

Treatments	Topping days from sowing		Yield of seed cotton lb./acre			Bartlett's earliness index
	1958–59	1959–60	1958–59	1959–60	Mean	
A	53	62	168	112	140	0·73
B	71	69	209	105	157	0·83
C	81	77	204	121	162	0·88
D	90	85	196	79	137	0·88
E	100	93	222	115	168	0·99
F	Control	..	212	91	151	0·84
		S. Em. ±	27·8	7·3	31·3	0·06
		C.D. at 5%	Not sig.	21·9	Not sig.	0·179

the results obtained for yield and earliness as observed by Bartlett's index under various topping schedules.

It is seen that topping at 93 to 100 days (treatment E) is found to appreciably increase the yield as compared to other topping schedules and control, in both the years. The mean yield differences are not significant. However, topping at 93–100 days has significantly induced earliness.

(2) *Effect of topping on the economic characters.*—Some observations made to study the variation in the economic attributes in relation to periodical topping have been tabulated in Table II.

TABLE II

Effect of topping on the economic characters of Westerns–1 cotton

Sl. No.	Economic characters	Treatments					
		A	B	C	D	E	F
1.	Weight of seed cotton per boll in gm.	1·50	1·36	1·28	1·34	1·29	1·39
2.	Number of seeds per boll	19·3	18·5	16·1	17·9	16·2	17·4
3.	Seed index ..	55·1	54·8	54·9	54·1	54·7	54·2
4.	Lint index ..	21·2	21·2	20·4	21·6	21·3	21·3
5.	Ginning percentage	28·5	28·8	27·5	29·2	28·6	27·7
6.	Halo length in mm.	20·4	20·9	20·8	20·8	20·8	20·2

It is evident from Table II that the economic attributes do not vary much due to periodical topping.

DISCUSSION

It was programmed to adjust the optimum time for topping the main axis, by which vegetative growth is checked in turn inducing the lengthening of the sympodial branches and early bolling. It is a common experience that prolonged vegetative growth delays the development of fruiting parts and will adversely affect the yield. In the westerns tract adequate moisture at crop period is a limiting factor. As such any method which can help in enhancing the yield and improving the earliness of crop has a significant role.

At Hagari five topping schedules were compared (53 to 100 days from sowing) with no topping for two years. Topping at 93 to 100 days from sowing showed an increased trend in yield (Table I). However, the mean differences were not significant. Guruswami Raja and Neelakantan (1958) recorded that topping does not enhance yield of cotton (*G. arboreum*).

As regards to earliness of the crop it is seen (Table I) that topping at 93 to 100 days has significantly induced earliness without sacrificing the yield. Earliness of the crop in the westerns tract is a prime factor. By adjustment of topping time it may therefore be possible to induce early arrival of the crop.

It may be seen (Table II), that by topping, the ginning percentage or Halo length of the type are not found to suffer.

Topping experimentation under irrigated cropping conditions with different agronomical treatments might give still more interesting results.

Summary

Topping of Westerns–1 cotton grown on the medium black cotton soils under rainfed conditions was tried at the Agricultural Research Station, Hagari, for two years 1958–59 and 1959–60. Periodical topping at 53–62, 69–71, 77–81, 85–90 and 93–100 days from sowing were compared to non-toppings and the results are discussed.

Acknowledgement

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POSSIBILITIES OF SUCCESSFUL COLONISATION OF *MELCHA ORNATIPENNIS* CAMERON FOR THE BIOLOGICAL CONTROL OF THE SUGARCANE TOP BORER, *SCIRPOPHAGA NIVELLA* FABRICIUS IN V.C. TRACT, MANDYA DISTRICT, MYSORE STATE

By Dr. M. Puttarudriah[1] and Syed Usman[2]

Successful colonisation has been obtained in initial field release trials with *Melcha ornatipennis* Cameron (Ichneumonidæ, Hymenoptera) for the biological control of the sugarcane top borer, *Scirpophaga nivella* Fabricius (Pyralidæ, Lepidoptera), a major pest of sugarcane, which is becoming increasingly serious in recent times in the Visvesvaraya Canal Tract, Mandya District, Mysore State. Following the encouraging reports (Gupta, 1959) of the utility of *M. ornatipennis* against the sugarcane top borer in Pugalur Sugar Factory areas, Tiruchirapalli District, Madras State, cultures of this parasite were obtained from there in August 1959 through the courtesy of Dr. R. D. Rege, Agricultural Adviser, Parry and Company, Madras, and Dr. S. A. Raja Rao, Entomologist, The Deccan Sugar and Abkhari Company, Ltd., Pugalur Sugar Factory, Pugalur.

Field Releases.—A thorough and repeated search made for this parasite in the sugarcane areas in the V.C. Tract showed that it was not present in the area before the present releases.

The culture received from Pugalur yielded 12 pairs of *Melcha* parasites. These were multiplied in the laboratory on the host larvæ in the suitable stage (Ahmed and Mathur, 1946). For this purpose infested sugarcane tops showing exit holes covered with parchment-like membrane and containing fully developed host larvæ were exposed to the parasites in small insect breeding cages, the atmosphere of which was made somewhat humid by placing moist sawdust at the bottom. Under these conditions the parasite completed its development in 17–19 days, which confirms the observations of earlier workers (Mathur, 1942; and Ahmed and Mathur, 1946).

A batch of 61 female and 12 male parasites thus obtained were released from 3–6–1960 to 6–6–1960 in the V.C. Farm in a ¾-acre plot

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containing about 3 months' old cane and showing heavy top borer infestation. Random collections of infested tops in the released plots made from time to time gave the following recoveries:

On 24–6–1960, *i.e.*, 18 to 21 days after release, 25 infested top shoots were collected; of these 12 tops, when split open, contained 4 parasitised host larvæ and one empty parasite cocoon, and from the remaining 13 top shoots, which were kept in a cage, one female parasite emerged.

On 10–8–1960, *i.e.*, 68 days after release, 60 infested top shoots were collected; of these 30 tops when split open, contained 2 parasitised host larvæ and 5 empty parasite cocoons, and from the remaining 30 top shoots, which were kept in a cage, 4 adult parasites were taken.

A further batch of 40 female and 16 male parasites were released in the same plot from 24–8–1960 to 29–8–1960.

On 13–9–1960, *i.e.*, 15–19 days after the second release, 50 infested top shoots were collected and kept in cages in the laboratory for observation. Ten days later they were split open and found 7 empty parasite cocoons, 1 parasite grub, which after six days developed into a female adult.

Again on 3–10–1960, *i.e.*, about 35 days after the second release, 70 infested top shoots were collected from 200 feet away from the released spot and kept in cages for observation; but only one female adult was recovered after a week, and one male after 9 days. The rest were split open and found 5 empty parasite cocoons and 1 cocoon with parasite.

On 24–10–1960, *i.e.*, 56 days after the second release, again 70 infested top shoots were collected from the neighbourhood of the released plot and kept for observation. After 9 days they were split open and found 4 parasite empty cocoons and 3 ill-developed grubs.

About 3 months later on 2–12–1960 500 infested top shoots were collected from the parasite released plot and kept in cages for recovery of parasites, from which 4 male and 10 female adults emerged from 2–12–1960 to 29–12–1960. Further collections of infested top shoots were made in the plot at the time when the sugarcane was harvested in January 1961 and were kept for emergence of parasites.

These initial observations definitely indicate that the parasite may gradually establish itself in the V.C. Tract and that it may prove useful in the biological control of the top shoot borer in this area.

More releases of the parasite on a larger scale are also being made and the results will be watched.

The good points in favour of this parasite as well as the details of its biology have been noted by Mathur (1942), Ahmed and Mathur

(1945) and Gupta (1959). As stated by Gupta (1959), when successful, this will be a case of an indigenous parasite colonising in an area of the country where it did not previously exist.

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The field trials were carried out by Sri. B. C. Somegowda, Assistant Entomologist and his Staff.

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CHOICE OF PARENTS IN WESTERNS COTTON (*G. HERBACEUM* L. VAR. *ACEREFOLIUM*) BREEDING AT HAGARI

By K. Krishna Murthy[1] and P. Nageshwara Rao[2]

Introduction

The role of heterosis and its exploitation in the improvement of cotton has been emphasised by several workers at the Eighth Conference of Cotton-Growing Problems in India held at Coimbatore during 1958. In a tract of erratic yields and uncertain and low rainfall like westerns, the choice of parents will have to be done with utmost care as maximum quality and yield will have to be combined in a type that can stand severe droughty conditions of the tract and can also come up with equal vigor as Westerns–1, even in the years of low rainfall. An instance of the utility of 1027 A.L.F. in preference to other parents is presented based on the experiments conducted during 1958–59.

Material and Methods

The relative merits of different parents and their contributions to improvements of Westerns–1 cotton were assessed by effecting crosses between Westerns–1 and 1027 A.L.F. Jayawant and B.C.–1, and testing F.-1 hybrids along with their parents in a randomised block replicated 4 times. The observations were recorded on 3 plants from each replication for all the variants under study. The results are presented in the Statement (Table 1) and the same are discussed below.

Discussion and Conclusion

The role of heterosis as mentioned already has been emphasised by several workers. Joshi *et al.* (1960) have dealt the subject in detail with particular stress on the crosses between hirsutum and barbadense hybrids and intra-hirsutum extracts. As far as westerns tract is concerned, the improvement brought out by the several Surat and Broach types was dealt by Satyanarayana Murthy and Rao (1956). Rao (1958) has further recorded that 1027 A.L.F. of Surat can be the most useful parent for qualitative improvements of the Westerns-1 cottons. The results presented in the Statement prove that 1027 A.L.F. is comparatively a more useful parent than Jayawant and B.C.-1 inasmuch as the

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TABLE I

Choice of parents in westerns cotton breeding at Hagari

Sl. No.	Variants	Final ht. of plant in cm.	Final No. of Nodes	Symp. Node No.	Symp. Node with boll	No. of bolls per plant	No. of flowers per plant	Yield of Kapas lb./ac.	Ginning %	Halo-length in mm.	Wt. of boll Dc. gm.	No. of seeds per boll	Test weight in Dc. gm. of	
													Seed	Lint
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	W. 1×1027 A.L.F. ..	65	21	9	12	9	28	255	33	23·9	13·2	15·1	59·5	28·5
2	W. 1× Jayawant ..	72	22	8	11	7	32	243	31	23·4	12·7	17·0	56·0	26·2
3	W. 1×B.C.–1 ..	69	21	8	10	8	35	251	28	22·4	11·6	14·6	57·0	23·0
4	1027 A.L.F. ..	62	22	10	15	7	27	247	33	22·3	12·6	14·6	61·0	29·0
5	Jayawant ..	69	21	8	13	6	30	228	30	21·3	10·8	15·6	52·0	24·7
6	B.C.–1 ..	64	23	9	11	7	29	238	27	22·0	12·3	13·8	64·0	24·2
7	Westerns–1 ..	63	20	9	12	6	32	240	27	21·1	12·3	16·0	56·0	24·7

hybrids of Westerns–1 and 1027 A.L.F. have excelled the other parents and their extracts from the point of yield as well as quality which is in agreement with earlier observation of Rao (1958). Crosses with B.C.-1 are found to record lower ginning and holo-length although their improvement in yield is favourable. It is therefore suggested that 1027 A.L.F. should be more utilised in Westerns Cotton Breeding.

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A NOTE ON THE DAMAGE TO SUGARCANE CAUSED BY THE BLISTER *ERIOPHYID* MITE

By Dr. M. Puttarudriah*

This unidentified species of *Eriophyid* mite was recorded by Van Hall (1923) in Java; and Horold E. Box (1953) in Queensland.

In India Muthukrishnan (1956) first recorded it in Madras State and described briefly the galls and the colony of mites in the erineum, the "acaro—cecidii". Regarding damage he stated that the erineum turned rusty-red due to laceration of the tissues and hardened afterwards.

Puttarudriah and Usman (1957) then recorded it in Mysore State describing in brief the external leaf-sheath scars, the internal blisters and the stages of the mite. They stated that no apparent injury on the cane proper was seen and that grown-up and young canes including ratoon were subjected to the attack.

Agarwal and Kandasami (1959) studied the nature of damage by this mite and stated that "the traumatic injury caused by these mites was simple and confined to the neighbourhood of the actual damage; the mites ruptured the epidermal cells and ejaculated some toxins and nitrogenous waste in the form of guanin, etc.; epidermal cells in the outer layer were largely flattened and destroyed; parenchymatous matrix and vascular bundles were more or less equally affected, the derangement manifesting itself by changes in size and shape of the cells.

Except for noting the gall-like blisters, erineum, laceration of the tissues and studying the flattening and destruction of epidermal cells, affecting parenchyma and the vascular bundles by the several workers cited above, other symptoms of damage to the growing cane and the loss thereof have not been noted.

Recently this lesser pest of sugarcane was seen to be spreading fast in several areas in Mysore State, and specimens of stunted young canes (seedlings) were received from parts of Shimoga for examination during 1960. On examining closely the specimens in the laboratory and also the standing affected canes in the fields it was noted that all the affected seedlings and young canes were stunted and the leaf-blades

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FIG. 1. Young Sugarcane showing mite-blisters on sheaths and twisted leaves with wavy margins (First Enlarged)

were twisted with wavy margins. On stripping them from the cane a large number of blisters in close proximity were noted on the tender sheaths of the twisted blades (Fig. 1). The extent of twisting of margins of the blades was closely related to the number of blisters on the sheath at the base. Larger the number of blisters near the base, greater was the twisting of blades. The blisters were full of mites in various stages. As the blisters turned old changing the colour from white to rusty-red the mites were also observed to migrate and crawl up along the tight fitting margins of the sheaths to colonise and form the blisters on tender sheaths in the spindle. Such affected seedlings became stunted and later dried up. This type of damage was seen more on the young canes of a ratoon crop around Bangalore and Shimoga. These observations have shown that it is necessary to keep a close watch on this pest and study it in all details for evolving suitable control measures should it become destructive on a large scale.

The photographs were taken by Mr. P. R. Raghuram Pillay.

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A NOTE ON THE OCCURRENCE OF *CACOECIA MICACEANA* WALKER AS A PEST ON GRAPE VINE

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Introduction

Though this insect was recorded for the first time on grape-vine around Bangalore by Usman and Puttarudriah (1955), it was not found so far in the pest form on this fruit-plant. During November and December 1960 it caused some concern in one of the grape-vine gardens at Kenchanahalli about 8 miles from Bangalore. Therefore this insect may be considered as a potential pest of grape-vines. Preliminary observations were made on its nature of injury, host range, incidence and extent of damage, control measures and natural enemies. A detailed study with regard to its biology and control measures is in progress, and will be published later.

Description of the Moth and its Stages

Moth (Fig. 1).—*Cacœcia micaceana* (Syn. *C. isocyrta* Mey., *C. epicyrta* Mey. and *C. machlopis* Mey.) is a bell-shaped, small moth belonging to the family *Tortricidæ*. It is brown in colour with a curve on the upper costal margin near the apex. Below the curve there is a dark patch with a dark spot. In the female when fresh, the scales on the upper wings present a ridged appearance. Wings overlap when resting. The lower wings are uniformly yellowish-brown. The apical margins are slightly frilled. The antennæ are slender (filiform) and slightly hairy at the segments. In the male the antennal segments are more beaded with short hairs. Dorsally on the thorax adjacent to where the wings overlap there is a white circular patch. Just above this there is a white spot; and two such spots laterally one on each side. The posterior part of the upper wing presents a wavy yellowish white band, the lower part of which extends broadly at the outer costal tip. In short, the upper wings are speckled with white and brown, broad patches of different patterns.

During the day they rest quietly as though they are inactive; but when disturbed they become very active and fly away. They are active

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after dusk. The males are attracted to bright light. Egg-laying takes place during nights, commencing two days after the moths emerge from the pupæ.

Egg.—Eggs are laid in masses varying in size, on the plant parts and also on glass surface in enclosures. They are greenish and not easily seen on green surfaces. The number of eggs in each egg mass varies from 7 to 58.

Eggs themselves are round or oval, generally light green laid very close together, frequently overlapping; held together by glutinous material. They become light-brown when about to hatch. Incubation period is about 8 days.

Caterpillar (Fig. 2 *a*).—The young caterpillar is yellow with a dark prominent head. It is active and feeds under a thin webbing on the epidermis of leaves. The full-grown caterpillar is about 20 mm. long; generally light green in colour, and has a dark green stripe along mid-dorsal line; scattered hairs arise from whitish small warts on the body; head round, shiny yellow-brown; prothoric shield dark-brown or black anteriorly edged with light-brown; thoracic legs black.

They live under white silken webbing (Fig. 3) and feed superficially on the epidermis of the plant parts.

Pupa (Figs. 2 *b* and 4).—It is about 10 mm. long and 3 mm. broad, light-brown with greenish tinge just after pupation, becoming much darker with age; lighter on ventral surface. Pupation takes place within the webbing; and the pupa is attached at the posterior tip. Pupal period is about a week.

Incidence and Extent of Damage

In the infested grape-vine garden, the damage caused by this insect on the grape bunches was conspicuously seen here and there. In each infested bunch 1 to 6 caterpillars were found feeding. On an average 12 berries from each infested bunch were found damaged (shrivelled). This pest was also observed during the same period in other grape-vine gardens round about Byatarayanapura, Yelahanka and Bangalore. But the incidence there was much less.

Food Plants

It is polyphagous and is recorded on many plants. Fletcher (1919) recorded it on green chillies; duranta shoots and fruits at Coimbatore; lantana leaves, flowers and fruits at Coimbatore, Bangalore, Shevaroys and Siddapur; orange leaves at Solan; on guava fruits, and lucerna leaves at Pusa; Mathur and Balwant Singh (1960) on *Gmelina arborea*; (1959) on *Dalbergia rubiginosa*, *Dillenia indica*, *Diospyros montana*,

Elæodendron sp.; and *Eugenia cominii*; (1958) on *Cullenia excelsa* and *Lantana aculeata*; Shroff (1919) on beans and tur in Burma; Usman and Puttarudriah (1955) on mango, grape-vine; Puttarudriah and Channabasavanna (1959) on Ragi (*Eleusine coracana*) around Bangalore.

During the present investigation, it was taken on neem leaves, *Glyricidia* leaves and shoots, citrus leaves, Honge (*Pongemia*) leaves, sandle leaves, coffee leaves, grape-vine leaves, bunches and berries, banana fruits, 'Ber' (*zizyphus*) and tomato.

Nature of Injury

Fletcher (1920) stated that the larva webbed adjacent flower heads and fed on the corollas, etc., as a rule; but it was sometimes found also on shoots or on ripe fruits which, later, it webbed up and fed on their dried pulp and bored into the seeds. Larvæ sometimes were found webbing up the leaves and feeding under cover of the webbing on the epidermis and mesophyll tissue of the leaves.

But during the present investigation larvæ were found to fold and sometimes roll up the adjacent leaves by webbing them together in a typical tortricid fashion and fed under cover of the webbing on the epidermis and mesophyll tissue of the leaves of neem, *glyricidia*, citrus, honge, sandal, coffee, Ber (*zizyphus*), tomato and grape-vine. Larvæ were also sometimes found gnawing into grape-berries, tender and developed, forming cavities at the base; and epidermis of unripe banana fruits. They were found feeding (scraping) (Fig. 5) on the epidermis of the main central stock of the grape bunches and also the fruit stalks. Caterpillars were also found in the harvested bunches brought to market. Depending on the extent of scraping on the main stalk near the secondary bunches the latter lost their attachment from the main and as a result the berries on such secondary stalks shrivelled up. So in the same attacked bunch some berries were shrivelled and the others were healthy (Fig. 6). Due to compactness of the grape bunches the larvæ were not seen from outside and some berries had to be removed to trace the larvæ within the silken tube-like webbing on the main stalk. The caterpillar was more a surface feeder though extensively than an internal borer. Serious injury to the plants was sporadic.

Control Measures

Indicative laboratory tests were conducted against this insect with the following insecticides at the concentrations shown against each of them:

1. Endrin 20% E.C. at 8 c.c. per gallon of water.
2. Malathion 50% E.C. at 8 c.c. per gallon of water.

3. Dipterex 80% S.P. at ½ oz. per gallon of water.
4. Parathion 46·7% E.C. at 3 c.c. per gallon of water.
5. Control (untreated).

Five grape bunches each containing three caterpillars were selected from a vine-yard and sprayed thoroughly with the respective insecticides. The results were as follows:

In case of Parathion and Dipterex all the three caterpillars were found dead after 24 hours from treatment. With Endrin two caterpillars were found dead after 72 hours and one caterpillar pupated on the 5th day. With Malathion one caterpillar was found dead after 72 hours and the remaining two caterpillars pupated. In the control no caterpillar died and all the three caterpillars pupated after six days.

Parathion and Dipterex indicated better results than others. However all the 4 insecticides and DDT 50% W.P. (1 lb. in 16 gallons of water) were used in spraying the individual plots in the orchard. Each insecticide was sprayed on 25 vines. The insect population count could not be taken before and after treatment because of the compactness of the bunches. The caterpillars could not be seen without removing some of the berries and causing some mechanical injury to the bunches. But however in some of the bunches where living caterpillars were suspected the number of shrivelled berries were marked before giving the treatment. In case of Dipterex and Parathion after treatment, it was observed that there was no increase in the number of the shrivelled (damaged) berries as compared to the number noted before treatment. Even in case of other treatments the same result was observed. The percentage of kill in each treatment could not be made out as it involved damage to berries. Another drawback in this case was that some of the caterpillars had pupated. Many were parasitised, and only a few were subjected to the insecticides.

The control of this insect within the grape bunches was difficult; because the developed berries in the grape bunches were so compact that the insecticides sprayed could not reach the central main stalk of the bunch on which the caterpillars fed. Even when drenching spray was given the liquid dripped down and wasted. Therefore with less pressure, the nozzle of the sprayer had to be directed at the base of the bunches so that the liquid flowed down the stalk.

Natural Enemies

A dipterous and an hymenopterous larval parasites have been reared from caterpillars. They are to be identified. The hymenopterous parasites were more common and helpful in checking the pest in nature.

Recommendations

Since this insect feeds on a number of host plants like lantana neem, honge, sandle and *glyricidea* in the vicinity of vine orchard it would be better if the vicinity is kept free from such plants. If *glyricidia* is grown for green manure, it must be cut frequently and kept free from the pest. The plants like *Citrus* sp., ragi, banana, coffee and tomato grown in the grape-vine gardens are also susceptible to the attack of this insect. If the insect is noticed on these plants immediately a spray of Dipterex or Parathion with a concentration shown above may be given so as to prevent the pest to migrate to the grape-vine.

The insect must be carefully looked for on grape-vine leaves and tender bunches and if noticed a spray with Dipterex drenching the interior of the bunches should be given before they become compact. (Dipterex is advised for a popular spray in view of its low toxic hazards.)

On compact bunches the spray must be made to drip down the central stalk of the bunches.

Acknowledgements

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FIGS. 1–6. *Cacœcia micaceana*. Fig. 1. Male and Female moths. Fig. 2. (*a*) Full-grown caterpillar. (*b*) Pupa. Fig. 3. Caterpillars removed from webbing. Fig. 4. Pupa attached in webbing. Fig. 5. Grape bunches showing epidermis of central stalk scraped by the caterpillars. Fig. 6. Some attacked bunches showing healthy and shrivelled berries.

General and Review Article

THE HISTORY OF PESTICIDES

By Dr. R. M. Greenslade*

Introduction

The term Pesticide is of comparatively recent origin and has rapidly come into use as a convenient word to describe any chemical substance which is used for the control of anything which is a pest—that is to say anything which troubles our crops, our stores of food, our buildings, our domestic animals or our own health. It is therefore a useful generic word for all such chemicals and saves the trouble of saying "insecticides, fungicides, nematocides and herbicides".

There are now so many hundreds of pesticides on the market and so many thousands more chemicals which are known to have pesticidal properties, that it is hard to realise how recently this development has taken place. Thirty years ago, there were only 9 or 10 insecticides in general use and one or two others whose use was dying out. There were still fewer fungicides and hardly any herbicides. Today it is almost impossible for the specialist to keep up-to-date with the multitude of organic chemicals which have been tested, or for the farmer to keep up-to-date with the multitude of proprietary trade names which he is offered.

The reason for this rapid development is not so much scientific as economic. Before the last war, chemical control of crop pests was almost entirely confined to fruit crops. Most fruit crops are perennials and remain in the same ground for many years. Insect pests and diseases therefore have the chance to build up to serious proportions; there is no rotation of crops to break the breeding cycle. Also most fruit crops suffer from a number of pests and diseases at the same time. The total loss of crop can therefore be serious. The urge to do something about control of pests was therefore greater than with an annual crop which could, if necessary, be ploughed up and sown again. Also since fruit is a luxury crop giving comparatively good financial returns, the grower could afford to spend money on sprays.

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Annual field crops on the other hand were hardly sprayed at all before the last world war. With the exception, perhaps, of peas, they rarely suffered from more than one serious pest in the season and the farmer was content to put up with a certain amount of loss. Sometimes he would sow extra seed so that the pests could take their toll and still leave him a reasonable crop. If they took the whole crop, he regarded it as an act of God and ploughed up the field to sow something else. In any case, he could not spray because he had no machinery suitable for the rapid treatment of large areas of land. No one manufactured such machinery because the farmer could not afford the capital cost of large machines which might only be used for a few days in the year. The situation in tropical plantation crops was much the name. The return in cash was never very high and the world prices were subject to violent fluctuations. When the price was low, the grower could not afford treatment against pests, and when it has high he thought there was no need to bother about pests.

During the war, however, the countries of Western Europe were hard-pressed for food, and the maximum return per acre was essential to survival. Guaranteed prices also gave the farmer the chance to make money, for the first time in 20 years, and he began to look for every possible way of increasing his output per acre. In addition, the increasing industrialization and shortage of man power began to take men away from the land. The wages of those who remained began to rise, a process which had been going on in America before the war. The output per man therefore also became of vital importance.

As soon as the farmer had money to spend and the need to spend it on pest control, the chemical and engineering industries were not slow to supply him with chemicals and machinery, and to put much of their own profits into research into better methods of pest control. Commercial rivalry in this field has esnured that the farmer is now plentifully supplied with cheap chemicals and machinery, and the situation has developed to the point at which, in Western Europe and North America at least, it has become economically impossible to grow crops without such aids.

Let us return to the history of all this development. The earliest pesticides were undoubtedly plant products, which by chance, were found to have insecticidal properties. In ancient times man could do very little about pests affecting his crops, but he was very concerned with those which infested his own body and kept him awake at night. He began to find that the leaves and flowers of certain plants, when dried and powdered, or steeped in water, would kill or repel such pests. No doubt witch-doctors and other " wise men ", who were generally

good naturalists, began to trade in such preparations. We know very little about these early developments but the evidence survives in the popular names of plants such as Lousewort, Bugbane, Fleabane, Chasse-punaise and many others in all languages.

Botanical Insecticides

Among these natural products there are some outstanding insecticides which have survived to the present day. One of the earliest was *Nicotine*. A home-made extract of tobacco leaves was certainly used as an insecticide on crops in 1746 and probably was known before that. Later the alcaloid, nicotine, was extracted and used as a contact insecticide and also as a fumigant. For some two hundred years it remained the best contact insecticide for commercial use and is still used, though it is disappearing because of its human toxicity and relatively high cost compared with the new synthetic organic insecticides.

Pyrethrum is another old plant insecticide. It was introduced to Europe just over a hundred years ago, but was used in the Far East much earlier. It has never found a market in agricultural use because of its lack of persistence, but for fly sprays and for use on stored foodstuffs its quick action and safety make it very valuable and the cultivation of the pyrethrum crop is still expanding, especially in East Africa. Again this is an expensive insecticide and much research has been devoted to synergists—compounds which increase the effectiveness of pyrethrum, thus making it effective at lower dosages. Research on the complicated structure of the active ingredients (pyrethrins) led to the synthesis, in 1949, of the allied substance *Allethrin*. Synthesis is however expensive, and allethrin has not so far replaced the cheaper natural product.

Rotenone which occurs in the roots of species of *Derris* (*Deguela*) and *Lonchocarpus* has been used probably for hundreds of years as a fish poison, and was used as an insecticide in Malaya before 1877. It was not extensively used in the West until after the 1914–18 war, but then began to be popular because it would kill insects not much affected by nicotine, it was somewhat more persistent and was less toxic to mammals. Right up to 1940, Derris and Nicotine remained the only two contact insecticides suitable for agricultural use. Its useful life came to an end with the discovery of DDT, but it is still sold in this country as a safe insecticide for the amateur gardener to use for caterpillar control on brassica crops.

Recently there has been a slight revival of interest in natural products as insecticides, and *Sabadilla* and *Ryania* have found a limited market in the U.S.A. *Subadilla* was introduced in 1944 as a fly spray and *Ryania* in 1945 as a stomach poison for certain lepidopterous cater-

pillars. It remains to be seen whether they can compete with the synthetic organic insecticides.

One noticeable character of the plant insecticides is their lack of persistence on the crop, and attempts were made to find insecticides which would give long protection and not require continual re-spraying. It was natural that attention should be turned to compounds of arsenic, which had long been known as poisons. Arsenious oxide was tried but caused damage to the crop foliage. Any soluble arsenic compound was ruled out on this account, and in fact, much later, they came into use as herbicides. The first successful arsenical insecticide was copper aceto-arsenite, known as *Paris Green*. This played a great part in the early struggle against Colorado Beetle in the U.S.A., starting in 1867, but is now no longer used. Its place was taken by *Lead Arsenate* introduced in 1892 and *Calcium Arsenate* introduced in 1906. These two had a long run and are in fact still in use, though now largely replaced by DDT and similar compounds. Lead arsenate is mainly used as a spray and calcium arsenate as a dust. The latter became very popular in the U.S.A. but was little used in Europe.

Synthetic Organic Insecticides

We come now to the synthetic organic insecticides. These can be conveniently divided into three groups: chlorinated hydrocarbon compounds, organo-phosphorous compounds and miscellaneous organic insecticides.

The most famous of the first group is, of course, *DDT*. This was first synthesised in 1874 but its insecticidal properties were not discovered until 1939 when Geigy were looking for compounds for moth-proofing textiles. Only those who were practical entomologists before 1939 can fully realise what a discovery this was. Up to that time we had persistent stomach poisons, such as lead arsenate, but no contact insecticide that would persist more than a day or two at most. DDT for the first time gave us an insecticide which could be applied as a residual insecticide. The spray deposit would remain active for several weeks on plants and several months on inert surfaces or in the soil. This really revolutionised our whole outlook on insect control and made it, for the first time, possible to control pests with which we had struggled hopelessly for years. In fact certain pests such as Apple Capsid Bug and Apple Blossom Weevil, formerly considered pests of the first order, are now almost forgotten by the youner gereration of fruit growers.

At about the same time *BHC* was discovered simultaneously in England and France. This again was a known compound which was first synthesised in 1825 by Michæl Faraday. He simply produced benzene hexachloride, but in 1912 van der Lindon showed that this is normally

a mixture of isomers. I.C.I. found that the insecticidal properties are mainly due to the gamma isomer, and that if this isomer could be separated from the others it did not give the objectionable taint to crops which results from the mixture. This isomer is now produced almost pure and is given the name *Lindane* in honour of van der Linden.

After DDT and BHC came into general use it was found that they had some disadvantages. There were for instance certain pests not easily killed, and research continued on chlorinated hydrocarbon insecticides in order to overcome these disadvantages. These developments took place mainly in the United States because at that time the pesticide industry was better developed there, and because of the stimulus to competitive research provided by the American cotton crop, which is probably the biggest single market for agricultural pesticides. *Chlordane* appeared in 1945 and *Toxaphene* in 1947. These were rapidly followed by *Aldrin* and *Dieldrin* in 1948 and by their stereo-isomers *Isodrin* and *Endrin* in 1951. *Heptachlor* followed in 1952 and *Thiodan* in 1956. All but the last are American products. All these have certain advantages over DDT and BHC. Chlordane for example is especially effective against grass-hoppers and ants, and is even less toxic to mammals than DDT. Aldrin is rather volatile and is therefore a good soil insecticide without the tainting properties of BHC. Dieldrin is very persistent. Endrin is toxic to certain mites and insects not easily killed by the other compounds. Toxaphene is cheap to produce, though the dosage required is high, and seems suitable for many cotton pests. Unfortunately, most of these are more toxic to mammals than DDT. Endrin in particular is very toxic, and can only be used on a few food crops under special conditions. The use of heptachlor has also been restricted recently because of the suspicion that residues could induce cancer.

Since the Shell Company acquired the rights to manufacture aldrin and dieldrin, their use has become universal, but chlordane, toxaphene and heptachlor have remained mainly for American use. Entomologists outside of the U.S.A. could at first find few advantages over BHC and DDT and by the time they needed other insecticides, the problem of insecticide resistance was beginning to be important. They therefore tended to look for quite different types of compounds, such as the organo-phosphorous chemicals, to supplement DDT.

The organo-phosphorous insecticides are the second large group of insecticides. This type of compound originated with the research of Dr. Schrader of Farbenfabriken Bayer in Germany. At the beginning of the last world war the Germans were short of nicotine and it was urgently necessary to find a good contact insecticide of similar properties. This led to the development of *HETP* (hexaethyl tetra phosphate) which was put on the market as Bladan. It was later found that the

main active ingredient of this was tetraethyl pyrophosphate, *TEPP*, and it is now generally referred to by this name. This has the same short persistence and high toxicity to aphids as nicotine. Schrader's researches also produced *Parathion* in 1944. This compound having more persistence than TEPP went a little way towards the greater persistence of the chlorinated hydrocarbons, and it has become one of the most widely used of insecticides—in spite of its great toxicity. About 1941, Schrader also discovered octamethyl pyrophosphoramide, which was later called *Schradan* in his honour. Neither parathion nor Schradan were produced commercially by the Germans at that time because they thought that it would not be safe to use such toxic compounds on agricultural crops, having regard to their greater persistence than TEPP. When the information about them became available after the war however, the Americans took up parathion with enthusiasm, and we in Pest Control Ltd. were particularly interested in Schradan. Schradan has low toxicity to most insects and almost no contact effect, but was not only very good against aphids by systemic action, but also was much more persistent than parathion. It gave us a very powerful selective insecticide which would protect crops from aphids for 6 weeks or more, without killing beneficial insects. It was the first practical systemic insecticide. Systemic action had been known for some years in selenium compounds, but their active ingredient is the poisonous element selenium itself, and since this does not decompose, these compounds cannot safely be used as insecticides. Schradan, though more persistent than most organo-phosphorous compounds, does disappear eventually from the crop. Schradan has now largely been replaced by other compounds which kill a wider range of insects but it still has a place for aphid control on crops which suffer repeated infestation by aphids and are harvested late, such as Brussels sprouts in the U.K. and walnuts in California.

Since 1945 there has been an enormous development of organophosphorous insecticides. Hundreds of compounds have been synthesised and many have reached the stage of commercial development. One of the earliest was *Demeton*, also one of Dr. Schrader's discoveries, marketed under the name *Systox*. This was quite widely used for a time as a combined contact and systemic insecticide, but like all O–P compounds to that date it was very poisonous.

About this time, due to the enormous increase in the use of insecticides, the public health authorities became very uneasy about the uncontrolled use of poisonous substances. There were already adequate safety regulations about the use of poisonous sprays, but both in Europe and the United States it began to be more difficult to get new products accepted. Government authorities began to ask for more and more

evidence of safety before they would allow their advisory services to recommend a product. This stimulated the search for safer insecticides and in 1950 the American Cyanamid Company produced *Malathion*, an organo-phosphorous contact insecticide of very low mammalian toxicity. This was a great step forward and the product found a wide market. However, it is not systemic and the dosage rate required for most pests is high and therefore expensive. Other materials therefore began to appear on the market. Bayer produced methyl demeton, or *Metasystox*, mainly effective against aphids and red spiders. Montecatini produced *Rogor* for olive fly control and this has been developed by Fisons Pest Control Ltd. for agricultural pests. From Geigy came *Diazinon*, which is one of the safest of all organo-phosphorous insecticides, but this is not systemic and finds its greatest market for the control of flies which have become resistant to DDT. Recently *Trithion*, *Guthion* (Gusathion), *Phosphamidon* and *Phosdrin* have been developed. Phosdrin is a systemic and contact insecticide of very short persistence. Guthion is of comparatively long persistence, though not so long as schradan. Phosphamidon is purely a systemic insecticide with poor contact action. Each of these has its uses in accordance with its mode of action, but all are poisonous materials which must be applied according to strict regulations and cannot be sold to the general public. They are therefore away from the general trend towards safer insecticides, and it remains to be seen how successful they will be.

An interesting development of organo-phosphorous compounds is their use as animal systemics. *Trolene* (*Korlan*) Dow Company and *Co-Ral*, Bayer, can be given to cattle for internal control of warble fly.

The third group or organic insecticides, neither chlorinated hydrocarbons nor organo-phosphorous compounds, is represented mainly by *Sevin*. This is a member of the carbamate family of compounds, which is a remarkable group containing fungicides, herbicides, nematocides and insecticides. Sevin shows promise for control of caterpillars and other insects and is very safe to use. It is of interest as a third line of attack against insects which have become resistant to both chlorinated hydrocarbons and organo-phosphorous insecticides.

Acaricides

When the chlorinated hydrocarbon insecticides were being developed it was found that they would not kill mites. In fact most of them encouraged mites by killing their natural enemies. This led to the search for good acaricides. The early acaricides were *Sulphur* and *Lime Sulphur*, and somewhat later, *Petroleum oil* sprays. These however were not always efficient, tended to injure or taint the crop, and presented difficult problems of compatibility in mixed sprays. A series of

compounds having specific acaricidal properties was then discovered. Some were sulphones, including *Sulphenone* by Stauffer Chemical Co. in 1945, *Genite* by Allied Chemicals in 1947, *Chlorfenson* (*Ovex* in U.S.A.) produced by Dow in 1949 and sold as Ovotran. *Fenson* marketed by Murphy in 1952 and *Tedion* by Philips-Roxane in 1954. A somewhat similar compound *Chlorbenside* was developed by Boots in 1953. At the same time, certain compounds similar to DDT were developed which were poor insecticides but good acaricides. *Dimite* marketed by Sherwin Williams in 1950 was followed by *Chlorobenzilate* of Geigy in 1952. *Kelthane* by Rohm and Haas appeared in 1955. Two other acaricides should be mentioned: *Azobenzene* which was tested as an insecticide in 1936, but introduced as a successful acaricide in 1945, and *Aramite*, produced by the U.S. Rubber Company in 1950. Azobenzene found its best market in the form of smoke generators for use in glasshouses.

Many of these acaricides have ovicidal properties and were therefore very useful for the control of Red Spider Mites in the summer when eggs and active stages are always present at the same time. However, the necessity for them has been lessened by the discovery of more persistent organo-phosphorous compounds which will kill adult mites and aphids in one spray, and will persist long enough to kill the next generation of mites when they hatch from the eggs.

Fungicides

The earliest known fungicide was *Sulphur*, mentioned 3000 years ago in Homer, and still in use. *Copper* compounds, though not quite so venerable, have been in use for over 200 years. In the course of time, various copper and sulphur compounds were tried, but the most successful were found to be *Bordeaux Mixture* and *Lime Sulphur*. Bordeaux mixture was used from 1842 in vine-yards in France to prevent theft of grapes near the roadsides, but about 30 years later the downy mildew disease appeared in France, and it was noticed that the treated grapes were free from the disease. This led to the general use of Bordeaux mixture as a fungicide. Lime sulphur was first used in about 1800.

Mercury is another old fungicide, dating back to 1755, when mercuric chloride was used as a seed-dressing against bunt disease of wheat.

For over a hundred years, Bordeaux mixture, sulphur dust, lime sulphur and inorganic mercury seed-dressings provided a technically good control of almost all fungus diseases of crops, except such groups as rust diseases, which were attacked by trying to breed resistant strains of crops. Their very success killed all initiative in research on fungi-

cides. It was not until about 1930 when the standard of crops required became very high, that their shortcomings began to be noticed. They all have a fairly narrow margin of safety to the crop, and they tend to be incompatible with the insecticidal sprays which often have to be applied at the same time. In response to the farmer's complaints one or two commercial firms began to experiment with such products as *Copper Oxide* and *Copper Oxychloride*, but it was up-hill work because, for all their practical advantages, they do not give such technically good disease control in one application. Mycologists in those days tended to be very much laboratory scientists, and unlike entomologists, were not well acquainted with the practical difficulties of disease control in the field. To the official mycologist in those days a copper preparation which was not technically as good as Bordeaux mixture did not seem worth using. The farmer on the other hand appreciated the ease of mixing and the lack of corrosion of his machinery and both copper oxychloride and copper oxide became well established, even though it was necessary to spray rather more often than with the older fungicide.

In the last 30 years, however, standards of crop safety and disease control have risen still further, and a new generation of practical mycologists has appeared on the scene and progress has been correspondingly rapid. A number of organic compounds have appeared which enable many of the old objections to be overcome. One of the first of these was *Salicylanilide*, which was marketed as *Shirlan* about 1930. This was offered for special purposes but the dithio-carbamate fungicides which appeared somewhat later were introduced as better replacements for copper and sulphur. *Ferbam* and the related *Thiram* (TMTD) were developed in America just before the war, and *Zineb* came in 1943. The equivalent manganese salt, *Maneb*, did not appear till 1950. By now Zineb and Maneb are the most widely used organic fungicides. In 1949, *Captan* was introduced as a substitute for sulphur on tree fruit crops and was immediately successful. Disease control was as good as with sulphur but the yield and quality of the fruit were considerably better. The most recent major introduction is *Karathane*, which is particularly useful against powdery mildews.

Most of the organic fungicides are quicker in action than copper, but not so persistent. There has therefore been a trend towards mixed sprays to take advantage of both properties. In a season when the onset of disease is rapid, the organic—Zineb for instance—checks the disease better, but in a season with slow build-up, one application of Zineb alone would not last long enough. In this case the copper part of the mixture gives the best control. This type of mixture is of particular value in the Western European climate where the nature of the disease outbreak—quick or slow—cannot be forecast from year to year.

The future development of fungicides lies in systemic fungicides, particularly if they have eradicant properties, that is, if they can kill the fungus *after* it invades the crop plant. Much research is currently going into this field, but no practical systemic fungicide has yet appeared. Various *Antibiotics* have been tested with some slight success but are not suitable for agricultural use and are in any case too expensive.

Herbicides

The history of herbicides is much shorter than that of insecticides or fungicides. This is natural enough, since weeds can be controlled by hand cultivation. In England, wheat used to be sown in rows 10 inches apart, and kept free of weeds by hand-hoeing. Horse-hoeing was an improvement on this, but the control of certain weeds was not very effective. The development of selective herbicides is entirely due to economic factors. In most countries it would now be impossibly expensive torely on hand-labour, even where sufficient labour exists, and chemical weed control is a necessity. It is hardly an exaggeration to say that if production of herbicides stopped, the wheat-eating nations would starve, and it may not be many years before the rice-eating nations find themselves in the same position.

Some of the earliest weedkillers were *Copper Salts*. Their action was discovered accidentally in France, Germany and America about 1895, in the course of fungicidal spraying with copper. *Copper sulphate* came into use as a selective weedkiller in cereal crops, followed in 1901 by *Ferrous sulphate*. In 1909 the use of *Sulphuric acid* was introduced and it remains in use still, though it is now more often used for burning off the green growth of potatoes before harvesting than for selective weed control. These materials depend upon the principle that their solutions run off cereals but wet the weed leaves. *Kainite* and *Ammonium sulphate* fertilizers were also used on the same principle; the weed leaves retained enough of the dry fertilizer to be scorched when it went into solution in rain or dew.

Progress was very slow, after these discoveries, until 1938 when rising labour costs stimulated research on weedkillers. In that year *DNOC* was introduced in France under the trade name of Sinox. Here we have the beginning of true chemial selectivity. The main effect of DNOC is still due to selective retention of the spray on the weed leaves, but cereals, even when wetted by the spray, are slightly more resistant than the weeds. In 1945 *DNBP* (*Dinoseb*) was introduced in America. This broke new ground because it could be used in peas and other crops. Previously only cereals could be treated.

All the herbicides mentioned so far killed only the above-ground parts of the weeds. This is satisfactory for annual weeds, but perennials

are only checked in growth. The next major step forward was therefore the discovery of the so-called " plant hormone " or " growth regulator " type of herbicide. *MCPA*, introduced in 1941 by Imperial Chemical Industries, was the first of these compounds and was closely followed, in 1942, by 2, 4–D in the United States. These compounds are said to have arisen out of academic research on the effects of natural plant " hormones " in which it was found that overdoses could kill plants by upsetting the co-ordination of growth. Their very great value to agriculture arises from a fortunate combination of several properties: (1) They are translocated in the plant and can therefore penetrate into the roots of many perennial weeds, (2) they are non-toxic to man, (3) They are used in plain water solution and can therefore be used in cheap low-volume machines, (4) they act at very-low dosage rates and are therefore cheap to apply.

These growth-regulating compounds, MCPA and 2, 4-D, changed the whole picture of weed control. They are so cheap and easy to apply that no cereal grower need try to do without chemical weed control. They also led to the present great development of low-volume spraying by ground and air machines, which has since been applied also to the application of insecticides and fungicides.

The great success of these compounds in controlling cereal weeds naturally led to the demand for weedkillers for use in other crops and for modifications to suit particular circumstances. Research soon supplied new materials and continues to do so. The original MCPA and 2, 4-D products were sodium salts of these acids. They still cover the bulk of the demand, but amine salts and esters have been introduced to kill more species of weeds, were slightly more risk to the crop can be tolerated. 2, 4, 5-T also appeared for bush control.

When these phenoxyacetic acids had been in use for some time, it was found that certain weeds were resistant to their action. Cleavers (*Galium*), for instance, was a major weed for which it was still necessary to use high volume spraying with the poisonous dinitro-weedkillers. Research eventually produced two answers to this problem—*CMPP* and *TBA*. CMPP would kill cleavers and most of the other cereal weeds; TBA could be added, at very low rates, to MCPA to enable the combined spray to kill all weeds. Both of these sprays will also kill chickweed (*Stellaria*). This is a weed which became increasingly common as a result of continued " hormone " spraying. It is quite resistant and benefited from the removal of competition from other weeds.

Naturally, farmers began to ask for weedkillers for use in other crops than cereals. This led to the development of other types of chemicals. *MCPB* and 2, 4-DB arose out of academic trials with

phenoxybutyric acids in place of phenoxyacetic. These are not herbicidal in themselves, but certain plants can convert them to MCPA and 2, 4-D. By a fortunate chance many common weeds can accomplish this conversion, but leguminous plants cannot. These compounds can therefore be used as selective weedkillers in clovers and other leguminous fodder crops. They are now quite widely used in this special field. 2, 4-*DES*, called *Sesone* in America, also acts indirectly. It can be sprayed on strawberries, for instance, without injury, but the spray which falls on the ground is converted by the moist soil into 2, 4-D which kills germinating weed seedlings. This compound is used to some extent in America, but has not found very wide acceptance in Europe.

In Europe, it was mainly the custom to spray after the weeds appeared, but in America, there was always a considerable demand for herbicides which could be applied to the ground before the crop emerged, to kill seedling weeds as they germinated. In a country where spring comes suddenly and there is little time for spraying after emergence of the crop it is perhaps natural that pre-emergence herbicides should attract interest. This technique is also very suitable for one of the most important of all American crops, maize (corn). The seeds are large and planted deeply and are therefore not affected by a herbicide applied to the surface of the soil. The shallower seeded weeds are easily killed. Among the first herbicides to be used by this technique was *CIPC*. This was found to kill chickweed and was introduced into Europe for use in sugar-beet crops, sometimes mixed with other pre-emergence herbicides.

Weeds of the grass family, especially Couch grass (*Agropyron*) and Wild oats (*Avena*) being very similar to cereals, are not killed by the early selective herbicides. However, it was found that *TCA* (trichloroacetic acid) would kill grasses if incorporated in the soil, and taken up by the grass roots. This opened the way to grass weed control in crops other than cereals, notably sugar-beet, kale and peas. It was also found that CIPC, if incorporated in the soil, would kill wild oats in a sugar-beet seedbed. The next step was *Dalapon*, which has the same action on grasses as TCA, but is absorbed by the foliage and therefore could be used after emergence of the grass, without soil cultivation. The final development of grass weed control, that is, the control of a grass weed in a cereal crop, seemed an unlikely proportion until *Barbane* appeared. This is a specific control for wild oats, and can be used in wheat or barley, and certain non-cereal crops. This has proved successful in two years of experimental use and will shortly be on the general market. Barbane (Carbyne) is applied after emergence and the wild oat seedlings and recently another compound, *Avadex*, has appeared which controls

wild oats by pre-emergence application to the soil. As yet (1960), it is too early to say how this will perform in practical use.

All the herbicides mentioned so far are selective herbicides. That is to say they are used for the selective control of weeds in crops. There are also certain herbicides which are generally used where it is necessary to kill all vegetation, such as on roads and railways and in places where dry grass in the hot season may present a fire risk. Some of these " total weedkillers " can however be used selectively in certain crops.

The oldest non-selective weedkillers are *Arsenical* solutions and *Chlorates*, and, developed somewhat later, the *Borates*. These all have serious disadvantages. Arsenicals are poisonous and can accumulate in the soil. Chlorates are very soluble and do not last long in the soil. They may also travel in the soil moisture out of the treated area and kill plants which were not intended to be killed. Also the vegetation killed by chlorates is very inflammable and it is necessary to add fire-inhibiting chemicals. Borates are not so effective as the others and are often used in mixtures with chlorates.

These materials are now tending to be replaced by two groups of total weedkillers, the substituted *Ureas*, developed mainly by Du Pont of America, and the substituted *Triazines*, developed by Geigy of Switzerland.

Among the urea herbicides, *Monuron* (CMU), *Diuron* (DCMU), and *Fenuron* (PDU) have been marketed so far, and among the triazines, *Simazine* and *Atrazine*. Apart from fenuron, the properties for which these compounds have been chosen are their very low solubility in water and their great stability in soil. This gives them very long persistence and weeds can be controlled by one application for a year. As a rule it is only necessary to apply a reduced " maintenance application " in subsequent years. The low solubility of these products, especially Simazine, enable them to be used selectively for weed control in deep-rooted crops such as fruit trees, and even fruit bushes such as black-currant and raspberry. In addition to this purely mechanical selectivity there is an interesting physiological selectivity in maize. The maize plant has the ability to absorb Simazine and break it down into non-toxic compounds before it reaches the site of action. These compounds are now at an interesting stage of development. The ureas and Simazine and Atrazine have established themselves as total weedkillers, and research is now concentrating on the selective uses of triazines and the use of mixtures to improve the performance against the more resistant weeds. In addition there are a whole series of experimental triazines, some of which have interesting selective properties.

Two other unrelated herbicides should be mentioned. These are *Aminotriazole* and *Maleic hydrazide*. These have been developed for special purposes. Aminotriazole is extremely mobile in the plant, and is translocated probably further into the roots of perennials than any other herbicide. It is being developed for control of bracken fern, which has enormous underground reserves and can defeat most herbicides by sending up fresh shoots, whenever the top growth is killed off. The technique used is to apply the herbicide when the foliage is expanded and protects the grass beneath. The herbicide is absorbed and translocated down to the underground organs which then fail to send up shoots in the following year. Unfortunately aminotriazole has recently been suspected of being capable of causing cancer. Maleic hydrazide is not strictly a herbicide, but a growth inhibitor. It slows down growth and reduces the amount of cutting needed. This is valuable for hedges and on sites such as railway banks where total destruction of the vegetation would lead to erosion.

The development of herbicides has been going on almost as long as the development of fungicides but their main development has been in the last 10 years and has been almost entirely due to research by industrial companies. The invention of new pesticides will probably always be in the hands of chemical companies but the development of their uses and the detailed study of what they will do in practical agriculture can also be undertaken by government and university scientists. This is what happens with insecticides and fungicides, but there are very few "official" herbicide research workers. In Britain an Agricultural Research Council team has been at work for some years under the disguise of academic research on agronomy and is only now (1960) being recognized as a weed control research team. Almost the whole cost of research on herbicides, from discovery in the laboratory, right up to the marketing of a product, has been borne by industry. The fact that industry has been willing to pay all this cost is an indication of the importance of the herbicide market, and thus of the value of herbicides to the farmer.

Nematocides

Attempts to control plant parasitic nematodes by chemical means are comparatively recent. Nematoes have undoubtedly affected crops for many years, but intensive cropping, with short rotations, has caused them to increase very considerably in the last 20 years. It is also likely that the damage caused by many species was not formerly recognized when so much more damage was being done by other pests and diseases. Research on control was stimulated mainly by the serious outbreaks of Potato Root Eelworm (*Heterodera*) on potatoes in Europe and the Root Knot Eelworm (*Meloidogyne*) on tobacco in Africa and

America. Various soil fumigants were introduced for their control and these have proved successful for the Root Knot species, but only technically useful for Potato Eelworm. The difficulty lies not so much in the efficiency of the chemical as in the economics of the crops. Soil fumigation is very expensive, and at present is only practical where the crop is profitable, the acreage is small and the dosage required is low. Tobacco and tomatoes are fairly profitable; they are grown on small acreages (and often it is sufficient to treat only the seedbeds, not the fields); the Root Knot Eelworm is fairly easily killed by fumigation. Potatoes and sugarbeet on the other hand are not so profitable in terms of financial yield per acre; they are grown on extensive fields, and not planted out from seedbeds; the Potato Eelworm is a cyst-forming species which requires very high dosages of fumigant for complete extermination. It is generally cheaper to grow potatoes on another farm for a few years until the worm population dies away naturally.

One of the earliest fumigants used against nematodes was *Chloropicrin*, but this is not particularly effective and is explosive. The first really successful materials were *Ethylene dibromide* (EDB), *Methyl bromide* and *D-D*. These were introduced as nematocides about 20 years ago, though the first two had already been in use for some 10 years as fumigants against insects. Recently other compounds have appeared. *Telone* and *Nemagon* are related to D-D, *Mylone* is a thiadiazine compound, *Vapam* is a thiocarbamate, *VC*-13 is an organophosphorous compound. *Yellow Oxide of Mercury* has been tried experimentally, but the mercury vapour which it releases will only travel a very short distance in the soil, and it therefore requires very thorough incorporation with the soil.

These products belong to very different groups of chemicals but all act by fumigation effect in the soil. They all vaporise rapidly from the surface of the soil and therefore it is difficult to keep an adequate concentration in the top layers of soil without expensive soil-sealing devices. They all show medium to high toxicity to growing plants at doses required for eelworm control, and therefore cannot be used satisfactorily in perennial crops such as tea or citrus.

It would appear that little progress can be made until some non-phytotoxic nematocide is discovered, perhaps a systemic compound which will kill the eelworms after they attack the plants.

Insecticides, Fungicides, Herbicides and Nematocides all started their development at different times, but in each case we can see a similar pattern of development. First, the discovery of a chemical which will kill some pests or weeds without injury to the crop. Next, a period when these few chemicals are used by some farmers but without much

enthusiasm. Thirdly, a sudden development of interest mainly brought about by economic circumstances. This leads to the discovery of new chemicals. At first these new chemicals seem wonderful, but widespread use shows that they have some shortcomings. This leads to the development of many modifications and still more new chemicals for special purposes. Such a process would logically lead to a special pesticide for each pest and each weed, but this is an unpractical ideal. It would confuse the farmer and, since the market for each chemical would be small, each chemical would be expensive. We may therefore expect to see manufacturers producing chemicals which kill as wide a range of pests as possible, in order to simplify production and keep down the cost to the farmer. Special modifications are only likely to be introduced where the demand is great enough to warrant the installation of special manufacturing plants.

In spite of the recent rapid development, this field of research is by no means exhausted, and it is probable that few of today's numerous pesticides will still be in use in 10 years' time. We are still waiting for:—

1. Systemic insecticides which will kill chewing insects.
2. Systemic fungicides which will kill fungi or bacteria after they have invaded the plant.
3. Soil insecticides which will persist throughout the growing season but not accumulate from year to year.
4. Non-phytotoxic nematocides.
5. Herbicides which can be used in a variety of vegetable crops.
6. Scrub-killing herbicides which can be applied from aircraft.
7. Chemicals which will protect plants against virus diseases, or cure the disease after the plant has become infected.

This list could be considerably extended, but it is sufficient to show that the outlook for chemists and biologists in this field is neither limited nor dull. It will not be the crop protection scientists' fault if anyone goes short of food in the future.

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PUTTING AGRICULTURAL PROGRAMMES INTO OPERATION

By R. Dwarakinath*

Introduction

All of us, engaged in extension work, are concerned about one thing; that is, finding simpler ways of doing better jobs. How can we put the village agricultural programmes into practice, more effectively? This question we keep asking ourselves all the time.

Essentially, our task is one of education; educating the farmers in matters relating to their daily work. There is always something new to be learnt, even in farming. It may be a new variety of crop, a new fertilizer mixture, a new technique of transplanting, or a new schedule of cultivation. Normally, such new knowledge comes from the research stations. It is the job of the extension worker to influence the farmers to accept and apply this knowledge to the needs and problems faced by them.

Teaching Involved

In order to influence people, the extension worker has to work, generally, with individuals; sometimes, with groups; and, occasionally, with the entire community. In popularising improved farm implements—a seed-drill, a pumpset, a bund-former, or a chaff-cutter—he concentrates his attention on the individual cultivators. In teaching plant-protection work—using a sprayer, preparing the bordeaux mixture, baiting field rats, or setting up light-traps—his focus is on the group of farmers affected by a problem. In stimulating collective action—improving gomal land, establishing a fuel plantation, desilting a tank, or raising a common paddy nursery—he approaches the whole community.

Education is stated to be the production of change in human behaviour in the desired direction. When we seek to influence people, the area of intended change may be their attitude (the way they feel); their knowledge (the things they know); or, their skills (the things they do). This task of influencing people to change involves teaching on the part of the extension worker, and learning on the part of the farmers.

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In fact, the changed behaviour is an end-product of the teaching-learning process. In itself, teaching consists of several component phases. Effective teaching is indeed leading the learners through these different steps. What are these steps in teaching?

Teaching Programme

A complete teaching programme consists of the following six analytical stages:—

(1) *Getting attention.*—The teacher draws the attention of the potential learners to the items to be learnt. The new idea or the improved practice to be taught is to be prominently brought to the notice of the farmers. The purpose is to make them aware of the things intended to be learnt.

(2) *Stimulating interest.*—After securing the attention, the teacher appeals to the basic needs and urges of the learners in order to arouse their interest in the subject-matter. There is relatively a deeper involvement of the learners, here. As things become meaningful to them, the learners concentrate their attention and their curiosity grows. They make a mental effort to know and understand, and thus become involved.

(3) *Creating desire.*—This is a further step along the line reached by the continued stimulation of interest. The learners respond and react. Their interest becomes a desire to know more of the matter to be learnt and to acquire it for themselves. This is the beginning of the motive for action.

(4) *Stabilizing conviction.*—The learners are, then, enabled to convince themselves that they can learn and that they have to put forth effort to learn. The growing motive becomes strong enough to compel action on the part of the learner. Besides, the prospect of satisfaction that results from achievements provides the necessary incentive. The learners make the determination to act and to learn.

(5) *Achieving action.*—Conditions are now created to facilitate conviction to be transformed into action. Learning does not take place without the " self-activity " of the learners. They have to undergo the learning experience as individuals in order to acquire the new knowledge, attitude or skills.

(6) *Deriving satisfaction.*—Successful learning always results in a specific satisfaction to the learners. It resolves the tension in the learners which had created the motive force for action. New learning thus meets the need or the urge of the learners to satisfy which efforts were put forth by them.

These are the six sequential phases constituting teaching. It should be noted, however, that these are not six separate parts, which, when put

together, would constitute good teaching. These are only the analytical aspects of teaching, identified individually in order to promote a better understanding of the total process. It is possible that all these stages are covered in one single teaching situation. It is also possible that several contacts between the teacher and the learners are necessitated to cover a single component phase of teaching. However, in practice, teaching is one indivisible activity.

Extension Teaching Methods

If extension is a teaching job, are there some extension teaching methods? Of course, there are, even though their enumeration and classification is not always uniformly done. Generally, they comprise of the following:

1. Farm and home visits.
2. General meetings.
3. Group discussions.
4. Result demonstrations.
5. Method demonstrations.
6. Campaigns.
7. Use of local leadership.
8. Exhibitions.
9. Study tours.
10. Literature.
11. Farmers' calls.
12. Radio programmes.

All efficient extension workers are conversant with the techniques of using these methods. They skilfully employ them, individually and in combination, for the specific purposes for which they are meant. Research as well as experience indicate that the effect of teaching will increase if a larger number of methods are used in respect of any teaching job, as indicated below:—

No. of extension methods used	% Change in farmers exposed to them
1	35
3	64
5	86
9	98

Therefore, for wider results, extension workers cannot rely upon one or two isolated methods, but will have to use a number of them and in proper combination.

We now understand that the nature of our job is teaching, that we have several extension methods for use, and that their combination in application has a definite influence on the outcome of the teaching efforts. How can we apply this knowledge to our daily work in the villages?

A Suggested Procedure

Of course, in areas where extension work is just beginning our first task is to get ourselves accepted. We should get to know the local people and their problems, win their confidence, and establish the channels of communication. With this end in view, individual contacts are made, leaders are located and acquainted with the programme, general meetings are convened, and institutions are approached by the extension workers. This is preliminary to and part of early extension work. It is the period of mutual acquaintance and understanding.

Let us also think of situations where extension work has been in progress for some time. This is a more general case. Here, again, the earlier illustrations may be helpful. Whether it is the individual work like use of farm implements, group work like adopting plant protection measures, or community work like gomal improvement, a general strategy of extension work is to be persued.

(1) *Build-up the basis for work.*—Local people know more about their problems. Talk with the informed persons and groups and get their thinking. Keep your eyes and ears open and observe things. Find out what people feel about your observations. Formulate a rough plan of work that meets the problems about which people are concerned. The extension methods which one may employ here will include individual contacts, study tours, group discussions, general meetings, interviews with leaders, and farmers' calls supplemented by observations and study of records.

(2) *Secure the approval of the Village Panchayat.*—This is a representative organisation of the people, which is growing in its stature and influence. Its approval or disapproval will matter a good deal to the success or otherwise of an extension programme. It is, therefore, necessary that the total plan of work—including individual, group and community work—finds the backing of the Panchayat. Many times there will be a Sub-Committee of the Panchayat for this work. Besides, the members of this organisation themselves may provide leadership in many lines of activity. One may employ here the methods of individual contacts, study tours, seminars and group discussions,

(3) *Discuss the plan in the Gramsabha.*—The Panchayat may discuss the annual or seasonal plan of extension work with all the farmers in the village. It serves the purpose of informing them, educating them, getting their thinking, securing their co-operation for further work, and thus preparing the ground. Group discussions, slide and film shows, study tours, etc., are some of the methods useful here.

(4) *Involve the interested individuals and groups.*—With the village agricultural programme now ready, the extension workers may begin its implementation, as illustrated below:

(*a*) *Gomal improvement work.*—This will be of interest to almost the entire village. Bring together the leaders in and outside the Panchayat to work out a detailed plan of execution. Help them to share responsibility and to put the programme into practice witn the participation of all concerned. Ensure the step-by-step guidance and assistance. Perhaps, the farmers could be enthused to undertake this work if individual contacts and group discussions are followed by illustrated talks by specialists, film shows on the subject, and study tours to other places where gomal improvement has been effectively done.

(*b*) *Plant protection work.*—This will be of interest perhaps to a smaller group of farmers. Some amongst them may be members of the Panchayat. Bring together those people in particular, who respond to your approaches and are generally interested in the issue. Work out a detailed plan of demonstration, popularisation and supply programme. Again, provide close guidance in its implementation. The extension methods employed may be the same as in the case of gomal improvement apart from the effective result and method demonstrations that may prove to be useful.

(*c*) *Use of improved implements.*—This will, of course, be a matter of interest to all farmers, but it is only the individuals that make decisions to buy and use them. Hence, this item of extension work relates to individual farmers, amongst whom may be some Panchayat members also. Here again, detailed plans must be worked out for demonstration and popularisation. Opportunity must also be taken, whenever demonstrations are organised, to involve as many of the prospective users of the farm equipment as possible. The burden of the work here is, however, on the extension worker and the farmer co-operating as demonstrator. Many of the extension methods used in the earlier cases along with systematic, preparatory and planned follow-up work with individuals may be employed for this task also.

(5) *Review the programme at the end.*—Some of the biggest lessons in extension are learnt when the work done is evaluated. Its rewards include the satisfaction we derive from achievements, and the insight

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we gain, into the failures and short-falls. Assessment of their own efforts and accomplishments by the people themselves is essential if they are to grow in their ability to face the problems and seek solutions to them. Evaluation may be done by the concerned people—individuals, groups or community or by competent outsiders. This assessment may be a simple one, or may be a sophisticated one. The extension worker may avoid doing this himself for the people unless he is fully confident that just criticism will be well received by the participants. However, he should invariably evaluate his own work.

Thus, in all these three lines of extension work, the first step is to commit the leadership of the village to a commonly acceptable programme based on expressed needs. The next step is to work with the concerned—the community, the group or the individual—for detailing and executing the plan. The third step is to evaluate the programme with the concerned to find out what has been done, and what else remains to be done.

Conclusions

One thing we should always remember: Extension is a continuous process. Once it begins, it moves from problem to problem, from achievement to achievement, and from one level of satisfaction to another. All the same, it is a slow process. Also, failures and frustrations are not rare. They will, of course, be too numerous if the extension workers lack the foresight, patience and perseverance so essential for this job. But, one may rest assured that extension work if pursued on proper lines will always yield results of lasting value and self-generating qualities.

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